

IGNIS

Buzzer-Only Low-Cost Carbon Monoxide Detection Prototype

Technical and Market Feasibility Brief

1. Project purpose

IGNIS is a student-built proof-of-concept exploring whether a simple, low-cost carbon monoxide early-warning architecture can be developed while clearly separating prototype functionality from certified safety performance. The project combines hardware prototyping, cost reduction, market sizing, affordability analysis, and route-to-market planning.

2. Executive summary

- **What it is:** A working carbon monoxide early-warning proof-of-concept using an Arduino Nano, MQ-7 gas sensor module, and active buzzer.
- **What it does:** Reads analog sensor values, compares them to a threshold, and triggers an audible alert when readings rise above that threshold.
- **Design choice:** The LED has been removed. The current version is buzzer-only to reduce cost and simplify the bill of materials.
- **Current cost:** Approximately US\$4.90, rounded to around US\$5 in small-quantity student-prototype form.
- **Cost-down pathway:** A sub-US\$3 version may be plausible after replacing the Arduino Nano with a low-cost microcontroller on a custom PCB and validating supplier pricing.
- **Boundary:** IGNIS is not a certified carbon monoxide alarm and should not be marketed as life-safety equipment without formal testing.

3. Device photograph and cost-labelled prototype

The photograph below shows the assembled buzzer-only IGNIS prototype. The main hardware elements are labelled with approximate small-quantity prototype costs. These figures are for prototype costing only and are not a supplier quotation or certified-product manufacturing cost.

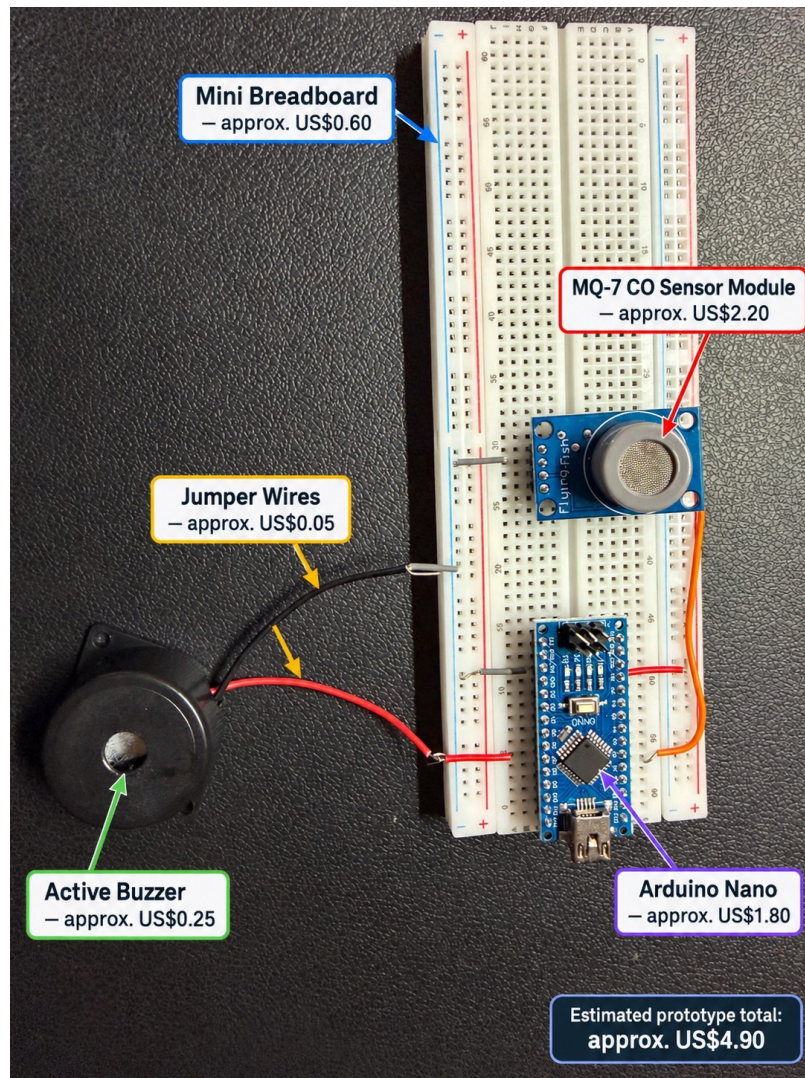
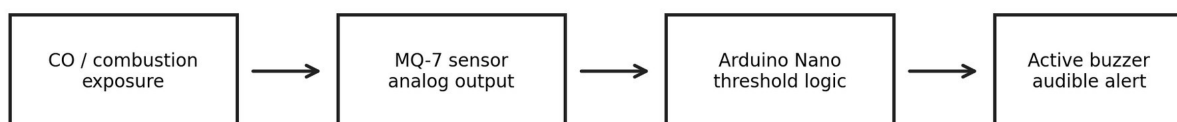


Figure 1. Annotated photograph of the assembled buzzer-only IGNIS prototype with approximate component-level prototype costs.

4. How the device works

- **Sensing:** The MQ-7 module responds to carbon monoxide-related exposure and outputs an analog signal.
- **Reading:** The Arduino Nano reads this signal through analog pin A0.
- **Threshold logic:** The code compares the live reading to a threshold set above normal-air baseline readings.
- **Alert:** When the reading exceeds the threshold, digital pin D8 turns on the active buzzer.
- **Recovery:** When readings fall below the threshold, the buzzer turns off.
- **Limit:** This is relative threshold detection. It is not certified ppm-level measurement.

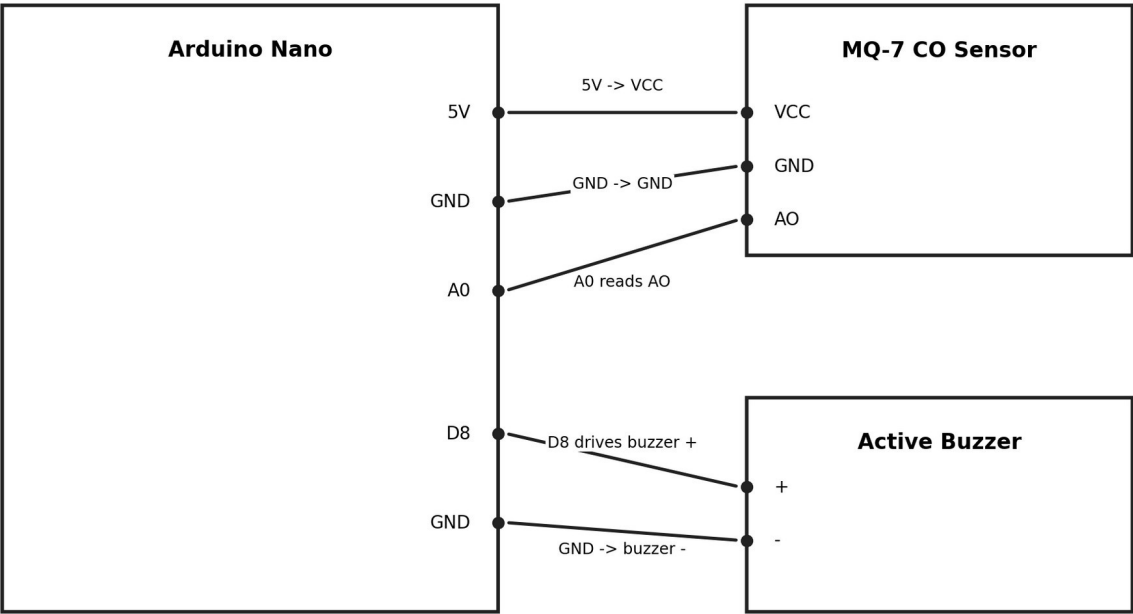


Buzzer-only prototype: prioritizes low-cost audible warning over visual display

Figure 2. Functional logic of the buzzer-only prototype.

5. Technology schematic

The current hardware architecture is intentionally minimal. The sensor provides the input, the Arduino executes the threshold logic, and the buzzer provides the output. The LED/resistor path has been removed by design.



Note: LED removed by design to reduce BOM cost and keep the prototype focused on audible warning.

Figure 3. Buzzer-only schematic: MQ-7 to Arduino Nano and Arduino Nano to active buzzer.

Connection	Arduino Nano pin	Purpose
MQ-7 VCC	5V	Power to sensor module
MQ-7 GND	GND	Common ground
MQ-7 AO	A0	Analog sensor reading
Buzzer +	D8	Audible alert output
Buzzer -	GND	Return path

6. Current prototype status

- Arduino Nano configured and programmed on macOS after resolving CH340 driver, bootloader, and USB-C adapter issues.
- Working configuration is Arduino Nano with ATmega328P processor setting, not Old Bootloader.
- MQ-7 produces live analog readings in the Serial Monitor.
- Buzzer activates when readings cross the programmed threshold.
- Current testing proves circuit function and directional response, not certified safety performance.

7. Cost per part and sourcing analysis

This section uses AI-assisted desk research and supplier screening to estimate where the cost can be reduced. The figures are indicative only. They must be confirmed through supplier RFQs, shipping and duty calculations, quality-control costs, and engineering validation.

Current buzzer-only prototype cost

Component	Prototype item	Estimate	Comment
Controller	Arduino Nano clone	\$2.00	Useful for prototyping but too expensive for production
CO sensor	MQ-7 module	\$1.20	Main sensing cost and the most important sourcing risk
Buzzer	5V active buzzer	\$0.35	Only alert output in current buzzer-only design
Prototype wiring	Breadboard and jumpers	\$0.60	Prototype-only cost, removed in PCB version
Assembly	Manual student build	\$0.50	Planning allowance for student-built version
QA/packaging allowance	Basic allowance	\$0.20	Not formal QA, included to avoid pretending the BOM is zero beyond parts
Visual indicator	Removed	\$0.00	LED and resistor intentionally omitted to simplify the BOM
Total		~\$4.90	Rounded as around US\$5 for the current prototype

Cost-down route

Component	Target cost	Change required	Validation needed
Microcontroller	\$0.16-\$0.30	Replace Nano with a low-cost MCU on a custom PCB	Confirm ADC resolution, GPIO count, programming method, and firmware support
MQ-7 sensor/module	\$0.65-\$1.00	Bulk-source MQ-7 or integrate the sensor conditioning circuit	Supplier RFQ, quality screening, and calibration repeatability
Buzzer	\$0.16-\$0.22	Bulk-source active buzzer	Confirm loudness, voltage range, and current draw
PCB	\$0.15-\$0.25	Use compact 1-2 layer board instead of breadboard	Quote using actual Gerber/BOM files
Assembly	\$0.20-\$0.35	SMT plus limited through-hole assembly	Check whether sensor and buzzer assembly are manual or automated
Enclosure	\$0.25-\$0.40	Simple plastic or locally made casing	Needs ventilation slots, sensor exposure, and durability testing
QA/packaging	\$0.15-\$0.25	Functional test and warning leaflet	Required to avoid unsafe deployment claims
Modelled V2 total	~\$2.80-\$3.00	Plausible only after custom PCB and supplier validation	Not a formal quote
Stretch target	< \$2.00	Possible only under higher volumes and strong sourcing outcomes	Not achieved and should not be claimed as current cost

8. Market size, affordability, and CO-risk proxy

The market model is proxy-based, because public state-level carbon monoxide poisoning data is uneven. It does not claim direct CO incidence by state. It ranks likely priority markets using exposure, affordability, and route-to-market logic.

- **Exposure proxy:** Unclean cooking-fuel reliance, rural combustion exposure, and high-risk settings such as poorly ventilated rooms, community kitchens, worker housing, hostels, and generator-adjacent spaces.

- **Affordability proxy:** Rural monthly per-capita consumption expenditure, used to estimate the burden of a US\$5, US\$3, or US\$2 device.
- **Market-size proxy:** Estimated households multiplied by unclean-fuel share. This is a rough high-risk household proxy, not a direct count of households needing a CO alarm.
- **Practical channel proxy:** Ability to reach users through CSR programs, NGOs, schools, institutions, or later government procurement.

State	High-risk household proxy	US\$3 burden of rural MPCE	Priority logic	Recommended route
Uttar Pradesh	26.5M	1.6%	Tier 1 scale market	CSR/NGO first, government later
Bihar	17.5M	1.5%	Tier 1 affordability and need market	CSR/NGO first, government later
West Bengal	13.2M	1.5%	Tier 1 scale market	CSR/NGO first, government later
Madhya Pradesh	11.5M	1.6%	Tier 1 scale market	CSR/NGO first, government later
Rajasthan	10.5M	1.2%	Tier 1 scale and institutional market	Institutional and CSR
Odisha	6.7M	1.6%	Tier 1 high-risk proxy market	CSR or NGO pilot
Jharkhand	6.0M	1.9%	Tier 1 affordability-stressed market	CSR or NGO pilot
Chhattisgarh	4.5M	2.0%	Tier 1 affordability-stressed market	CSR or NGO pilot
Assam	4.6M	1.5%	Tier 1 northeast need market	NGO or school outreach
Karnataka	3.0M	1.1%	Best credibility/local pilot base	School, institutional, media pilot

9. Business and market-entry plan

The recommended route is not direct rural household sales. The strongest early route is institutional or CSR-backed validation. This reduces affordability barriers for users and avoids implying that the current prototype is a certified consumer product.

- **Best immediate route - school or safety outreach:** Use the prototype as a safety-awareness and technical-education tool. This is the most realistic student-led public-facing route.
- **Best validation route - CSR-funded NGO pilot:** A company funds a small supervised pilot through an NGO, school, or rural safety partner. Users do not pay directly, and the project fits preventive-health and rural-development themes.
- **Best paid early market - institutional B2B:** Target hostels, worker dormitories, small hotels, kitchens, clinics, and schools only after stronger testing. These buyers have budgets and duty-of-care reasons to care about alerts.
- **Government route - later only:** Government procurement through GeM or tenders could offer scale, but should come after testing, product redesign, and compliance review.
- **Weakest early route - direct household sales:** Large theoretical market, but poor launch fit because of trust barriers, affordability constraints, servicing burden, and liability risk.

Recommended sequence:

1. Use the working buzzer-only prototype to document technical feasibility and limitations.
2. Prepare a clean public-facing story around low-cost safety awareness, not product certification.
3. Use Karnataka as the credibility base because it is local and easier to document.
4. Use Uttar Pradesh, Bihar, West Bengal, Madhya Pradesh, Rajasthan, Odisha, Jharkhand, Chhattisgarh, and Assam as the need-led market narrative.
5. Prioritize CSR, NGO, school-safety, and institutional channels before any direct household strategy.
6. Consider government procurement only if the design is later validated, redesigned, and standards-reviewed.

10. Future roadmap

- **Now - documentation package:** Device photo, demo video, code, schematic, current BOM, baseline readings, and safety disclaimer.
- **Next - technical refinement:** Address architecture, testing gaps, calibration limits, sensor choice, cost assumptions, and responsible public positioning.
- **Testing upgrade:** Warm-up curve, normal-air baseline, threshold trials, response and recovery measurements, repeatability checks, and comparison against a reference detector if available.
- **Cost-down design:** Replace Arduino Nano with low-cost MCU, create PCB schematic, update BOM, and request supplier quotes.
- **Public communication:** Seek news or school coverage only after further testing and documentation, using language that describes IGNIS as a prototype and safety-adoption study.
- **Longer-term possibility:** A supervised pilot could be explored only if testing supports further development. This is not a current deployment claim.

11. Project materials

- actual device photograph
- 60-90 second demo video
- Arduino code
- circuit photographs
- schematic diagram
- bill of materials and cost-down model
- project development log
- baseline and triggered sensor readings
- safety disclaimer and limitations note

12. Sources and references

Pricing links are indicative and should be validated by supplier quotes. Standards links clarify the distinction between a proof-of-concept and formal product certification.

Source	Use	Link
WHO household air pollution fact sheet	Health and exposure context	Open source
Economic Survey 2021-22 NFHS-5 table	Clean-fuel proxy	Open source
MoSPI HCES 2023-24 fact sheet	Affordability proxy	Open source
Government e-Marketplace overview	Government procurement route	Open source
Companies Act Schedule VII	CSR eligibility context	Open source
Hanwei MQ-7 datasheet via Mouser	Sensor characteristics and limitations	Open source
LCSC HT66F002 MCU	Low-cost MCU benchmark	Open source
Alibaba MQ-7 example	Bulk sensor price benchmark	Open source
LCSC active buzzer example	Buzzer benchmark	Open source
JLCPCB PCB assembly price note	PCB/assembly costing basis	Open source
BIS fire detection standards programme	India standards context	Open source
EN 50291-1 overview	Domestic CO alarm standard context	Open source

Positioning statement: IGNIS is presented as a buzzer-only, low-cost CO detection proof-of-concept and market-feasibility study, not as a certified consumer safety alarm.